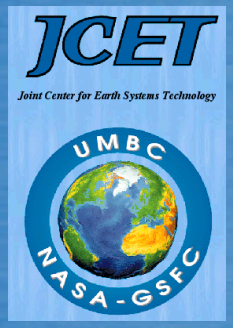
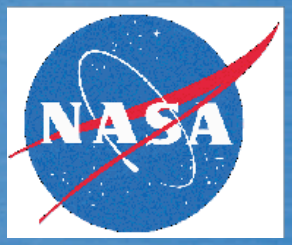




3D effects in MODIS observations

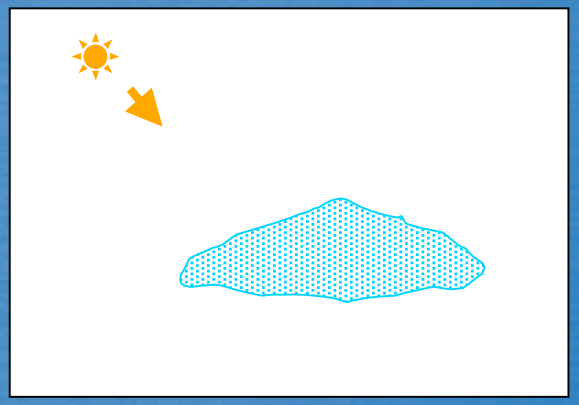
Tamás Várnai[1] and Alexander Marshak[2]

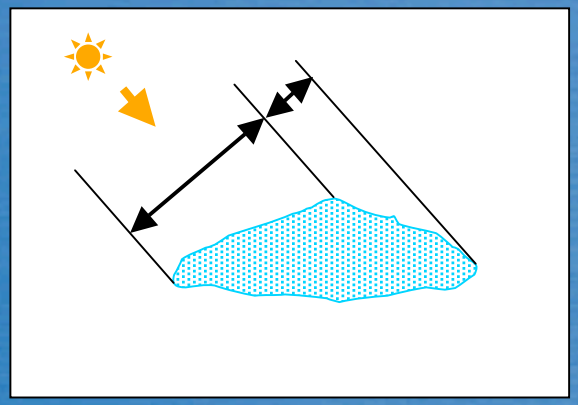
[1]Univ. of Maryland, Baltimore County, [2]NASA Goddard Space Flight Center

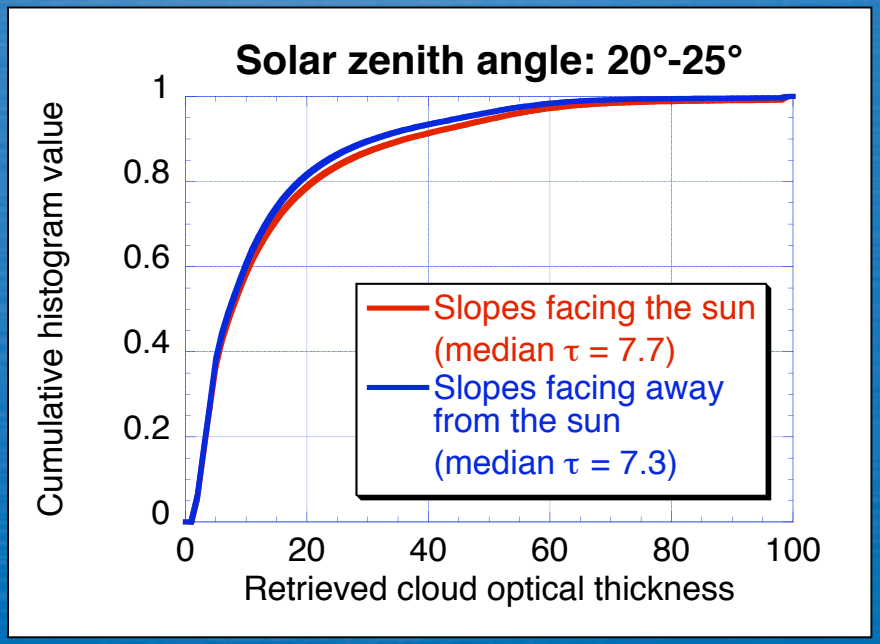
Outline

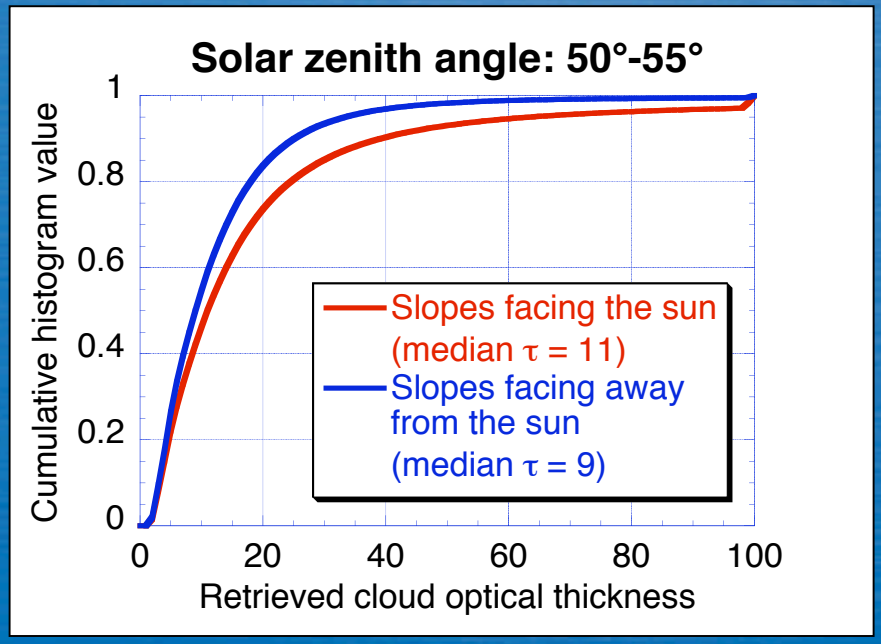
- Shadowy vs. illuminated cloud sides
- View-angle dependence
- 3D influence on effective radius retrievals

Shadowy vs. illuminated cloud slopes

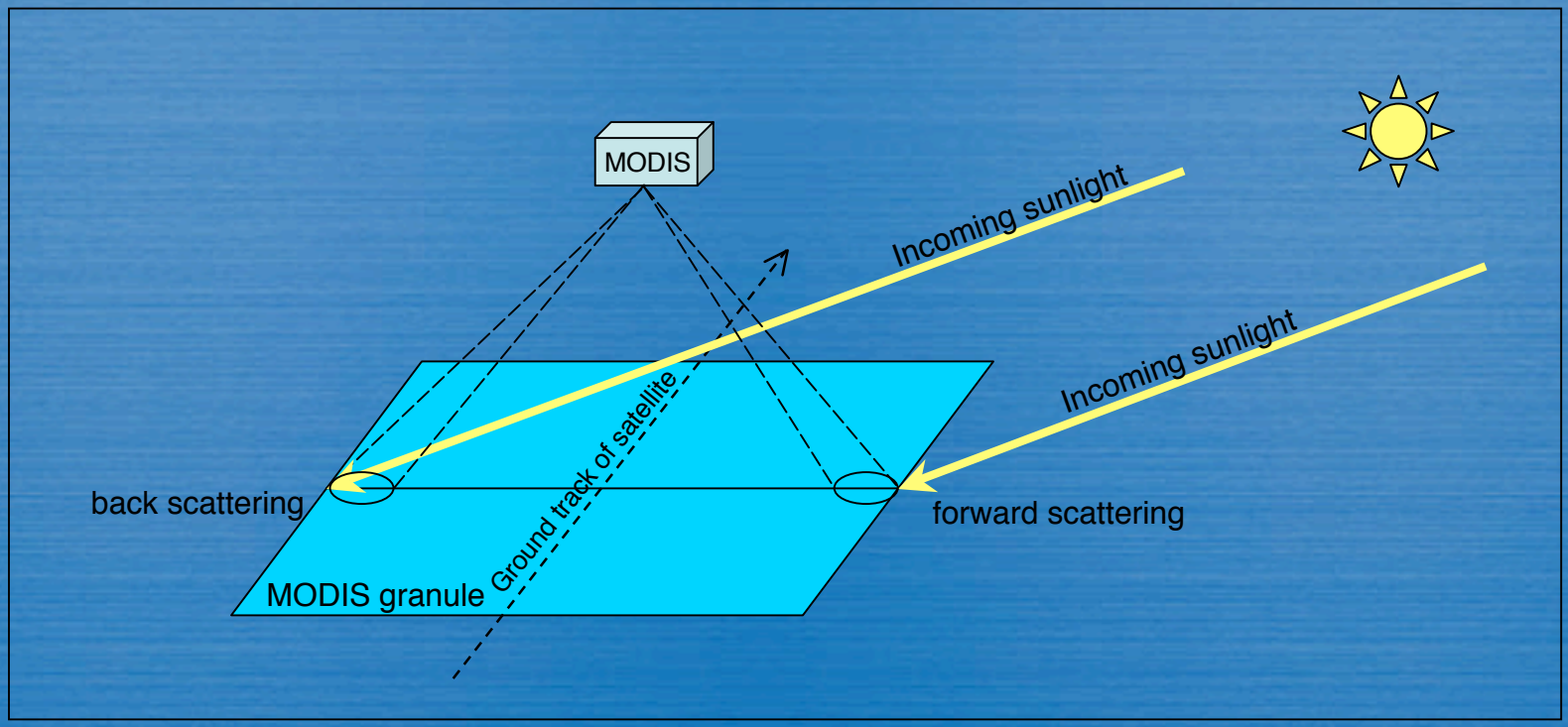








MODIS observation geometry



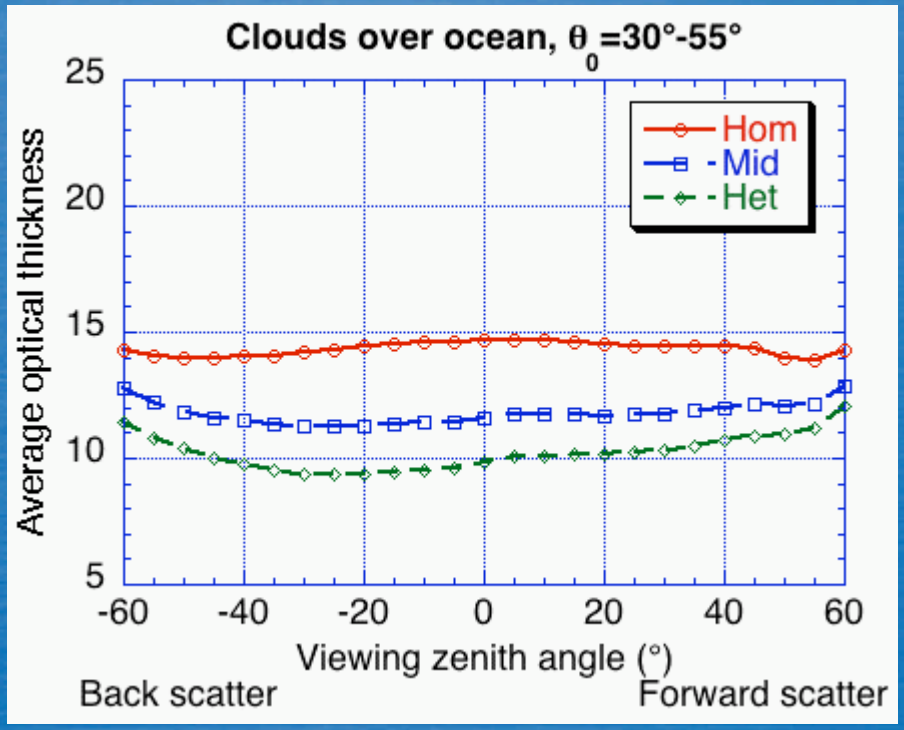
Relative azimuth ≈ 60° for oblique sun

Dataset

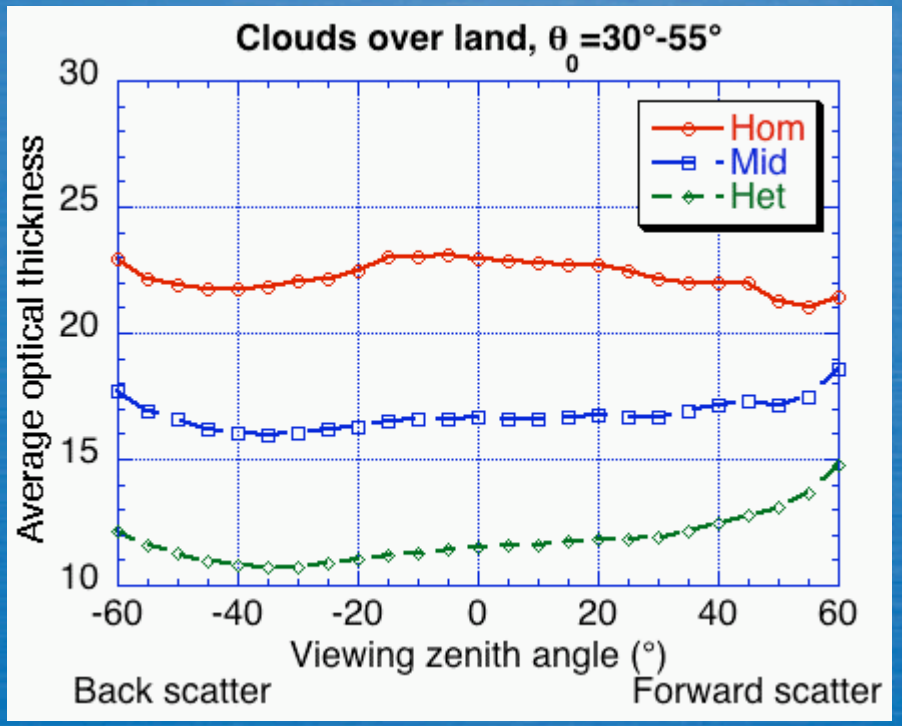
- Virtually all daytime granules for 11 months (8/2004-6/2005)
- About 7% of scan lines
- 11 μm BT and cloud products at 1 km resolution
- High-confidence retrievals
- Liquid cloud phase

High sun

Ocean

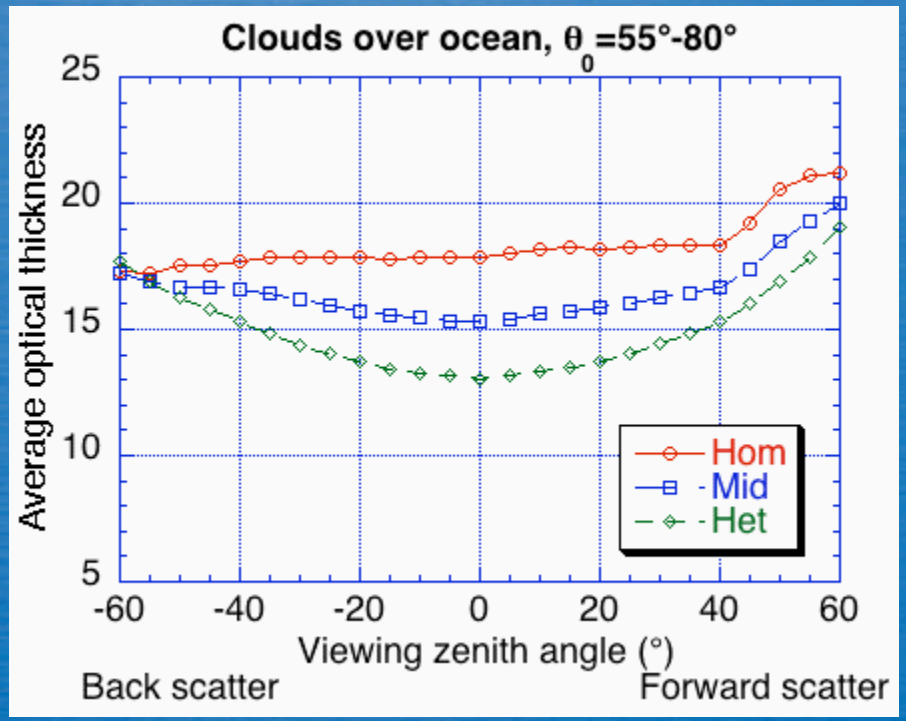


Land

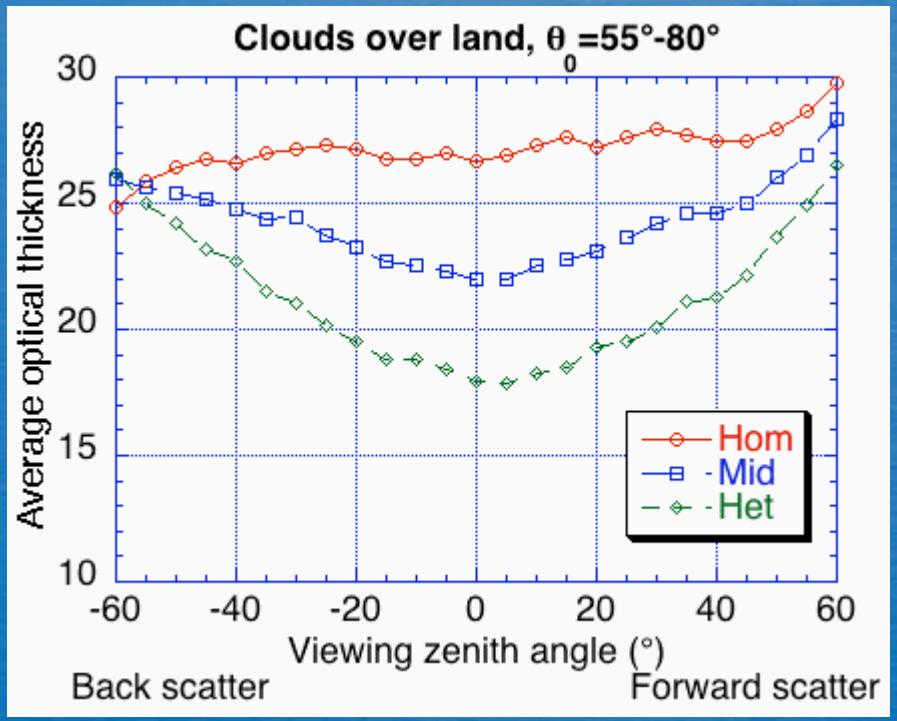


Low sun

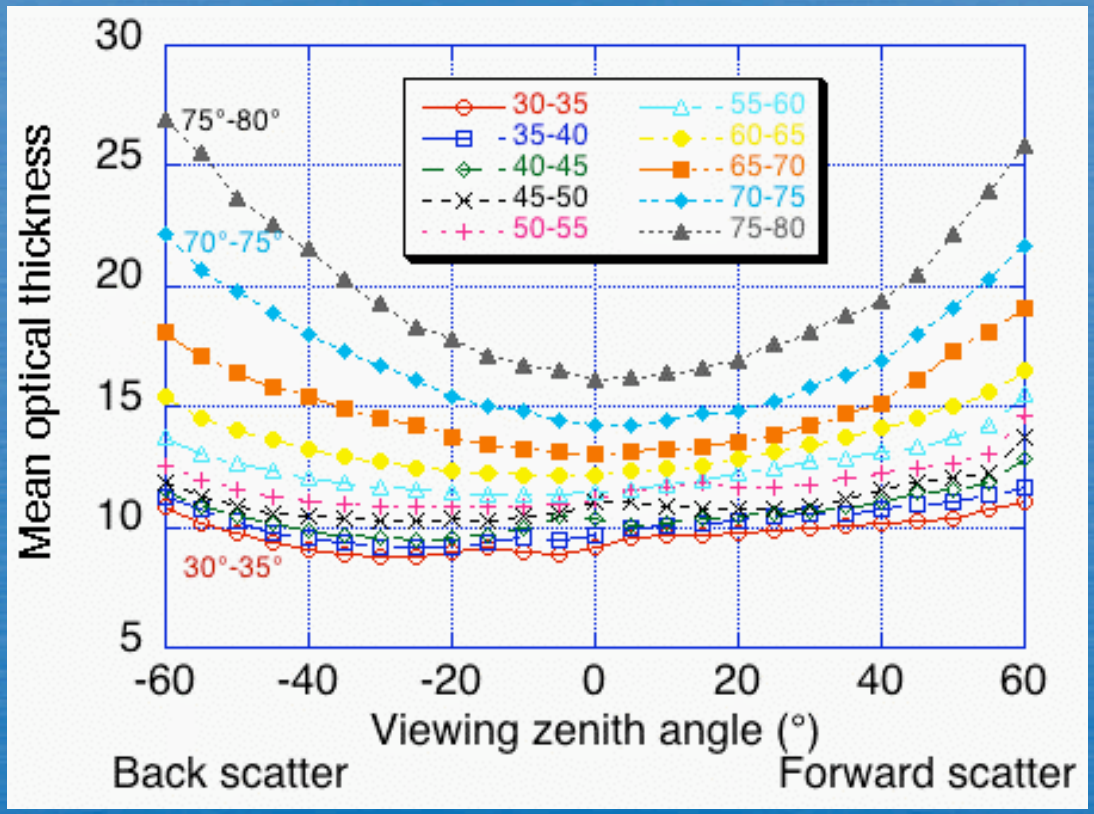
Ocean



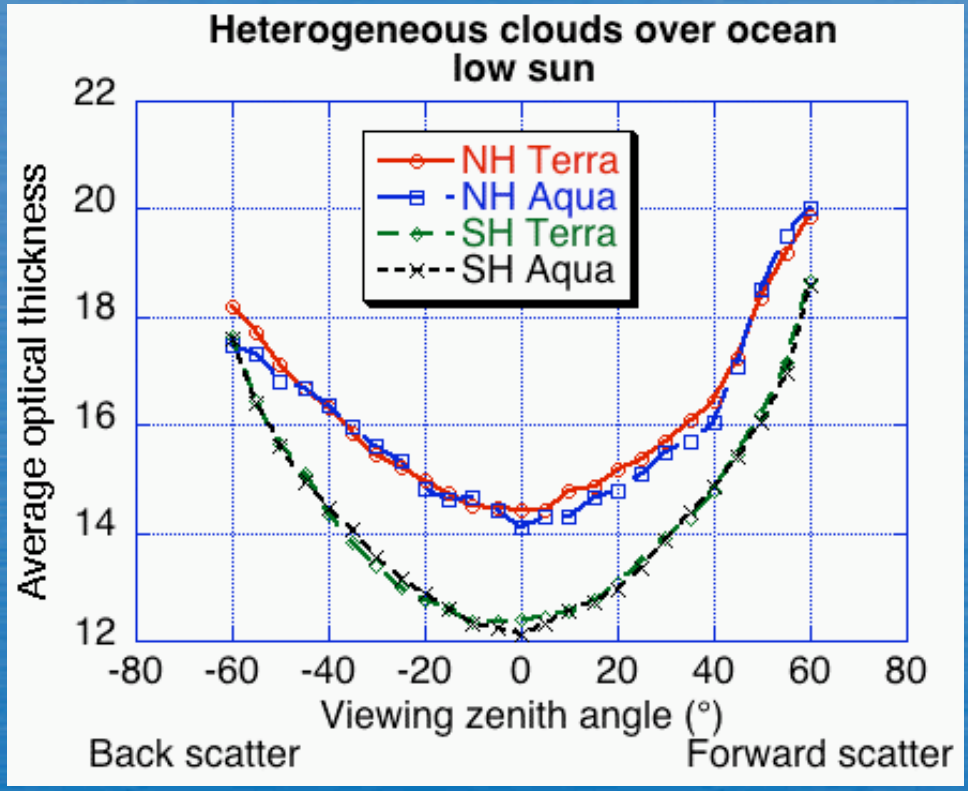
Land



Solar zenith angle dependence

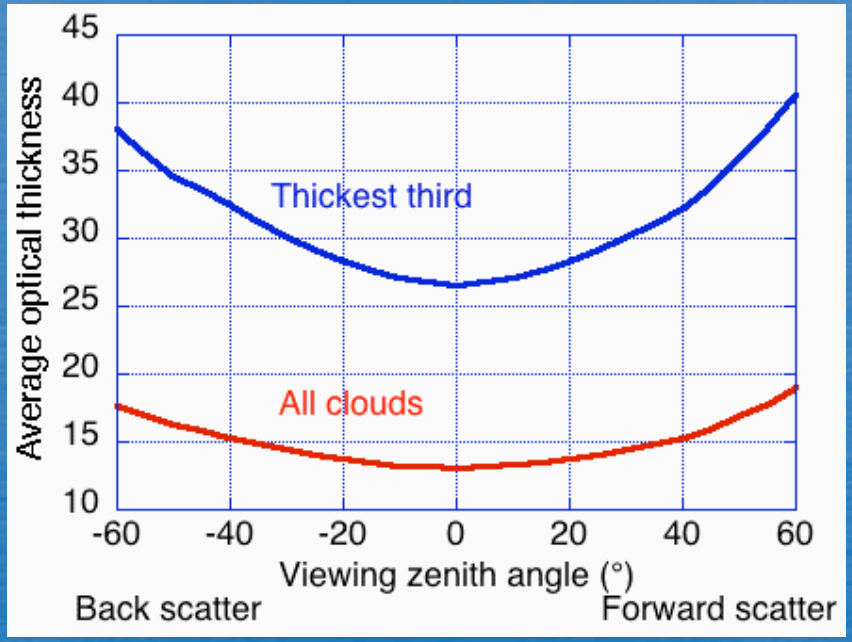


Is U-shape correct?



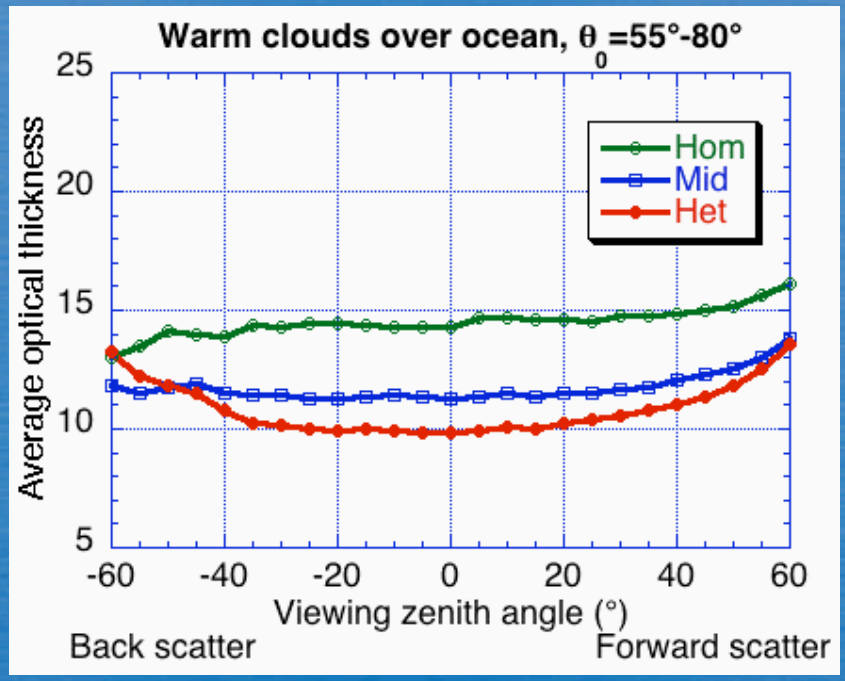
Could surface BRDF cause U-shape?

Thickest third of clouds



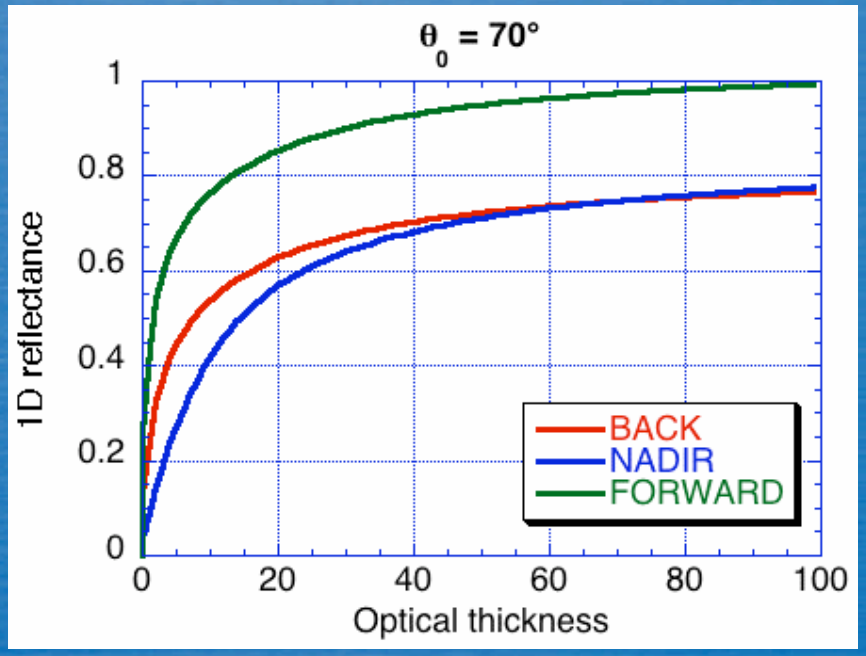
Could uncertainties in cloud phase cause U-shape?

Warm pixels (T > 0°C)

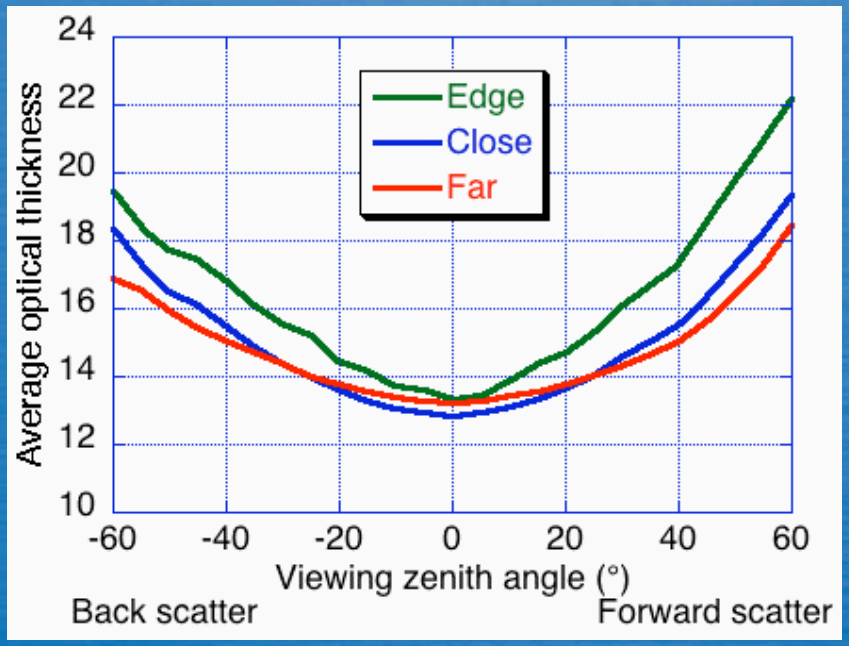


Clear-sky uncertainties (aerosol, gas absorption, Rayleigh scattering) unlikely

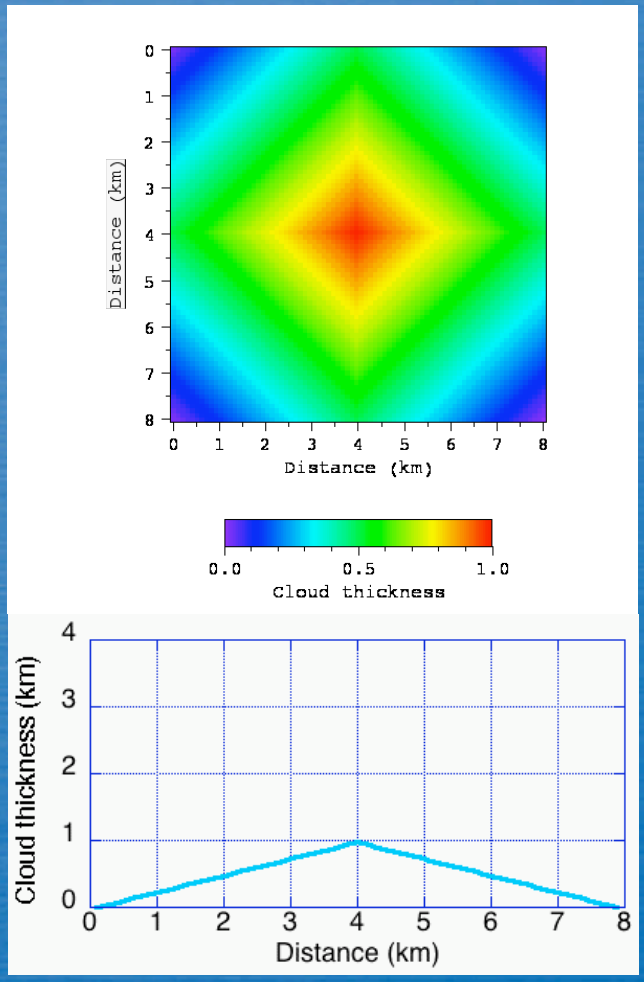
Could 3D effects cause U-shape?

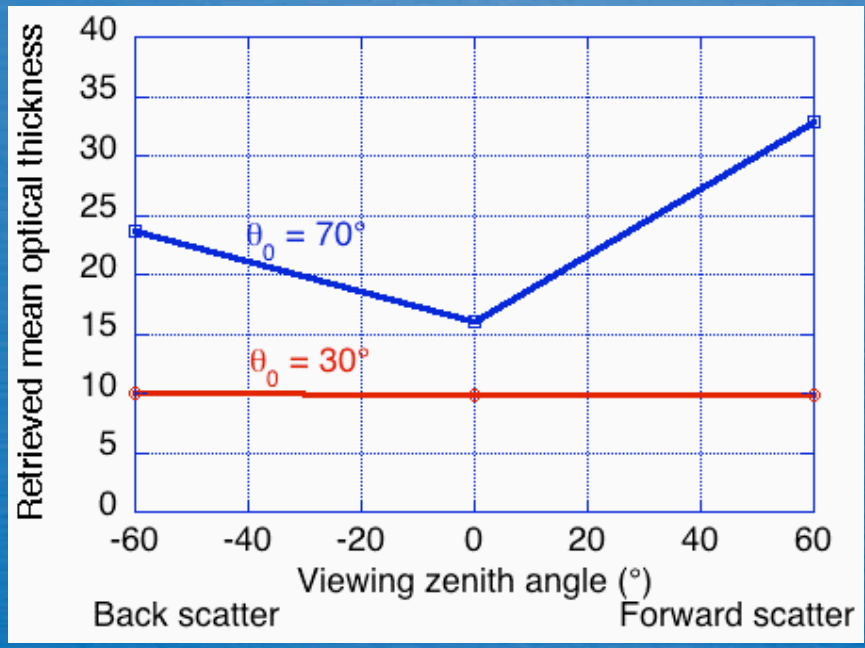


Pixels far from cloud edges



Could shadowing/side illumination cause U-shape?

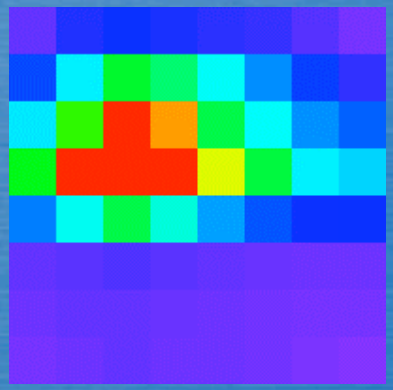




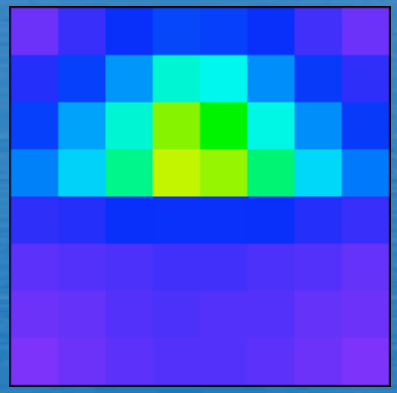
$\sigma = 20\ km^{-1}$ $0 \le \tau \le 20$

Retrieved τ-fields

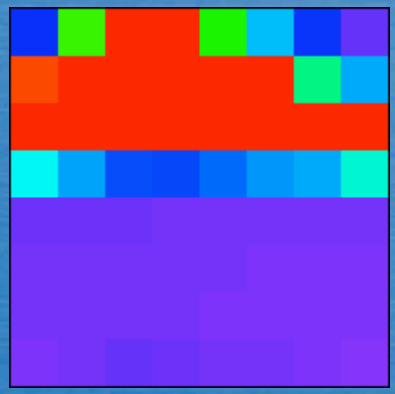
Back



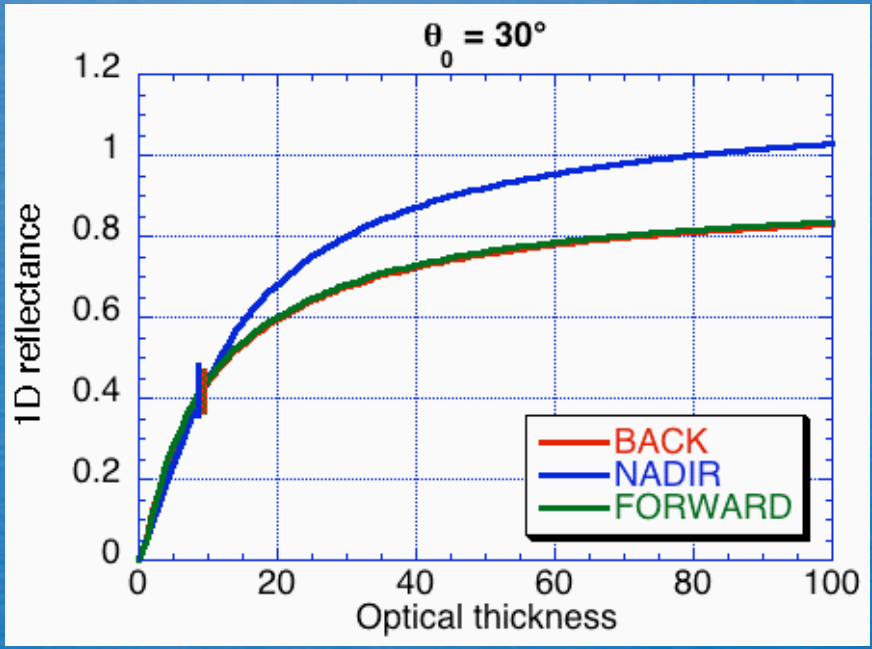
Nadir

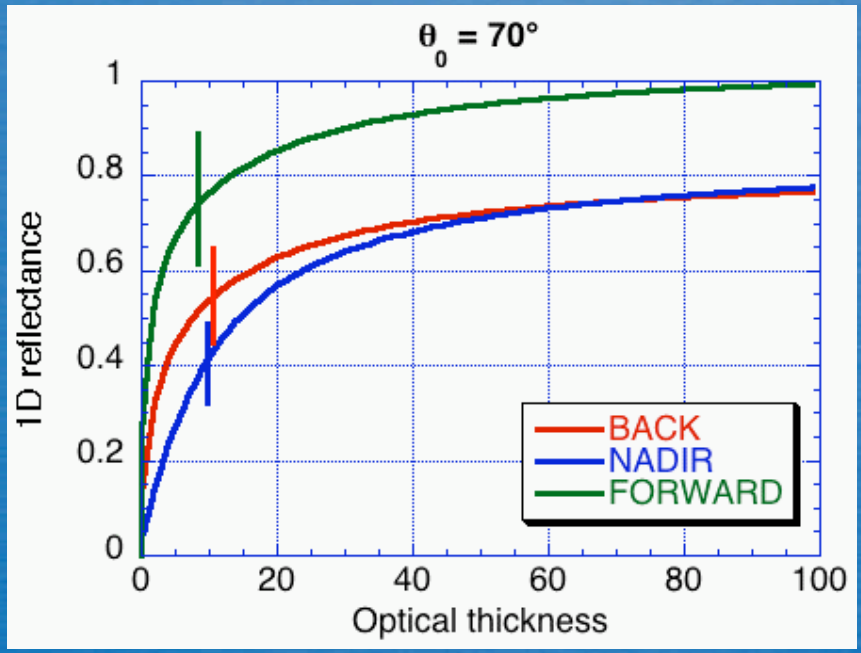


Forward

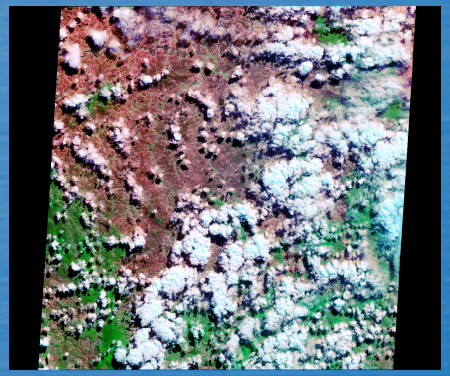


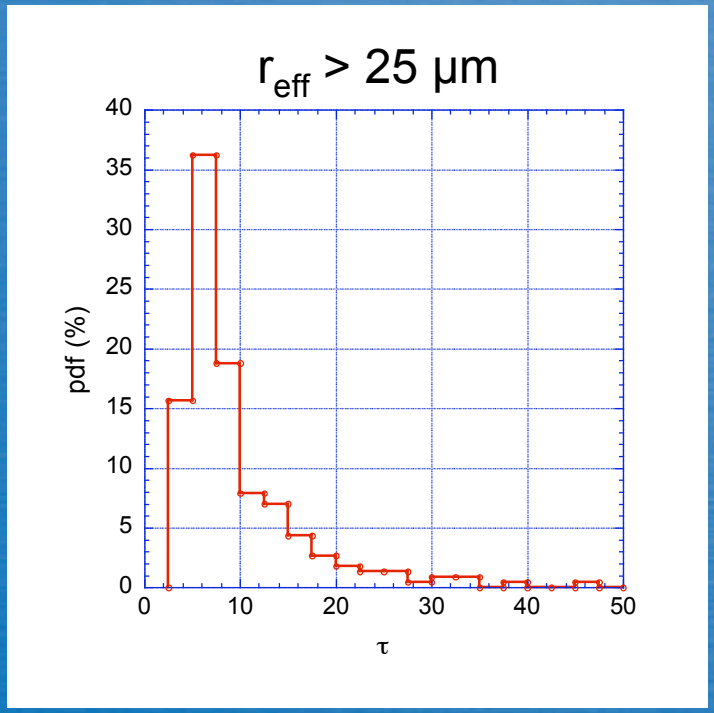
1D look-up tables

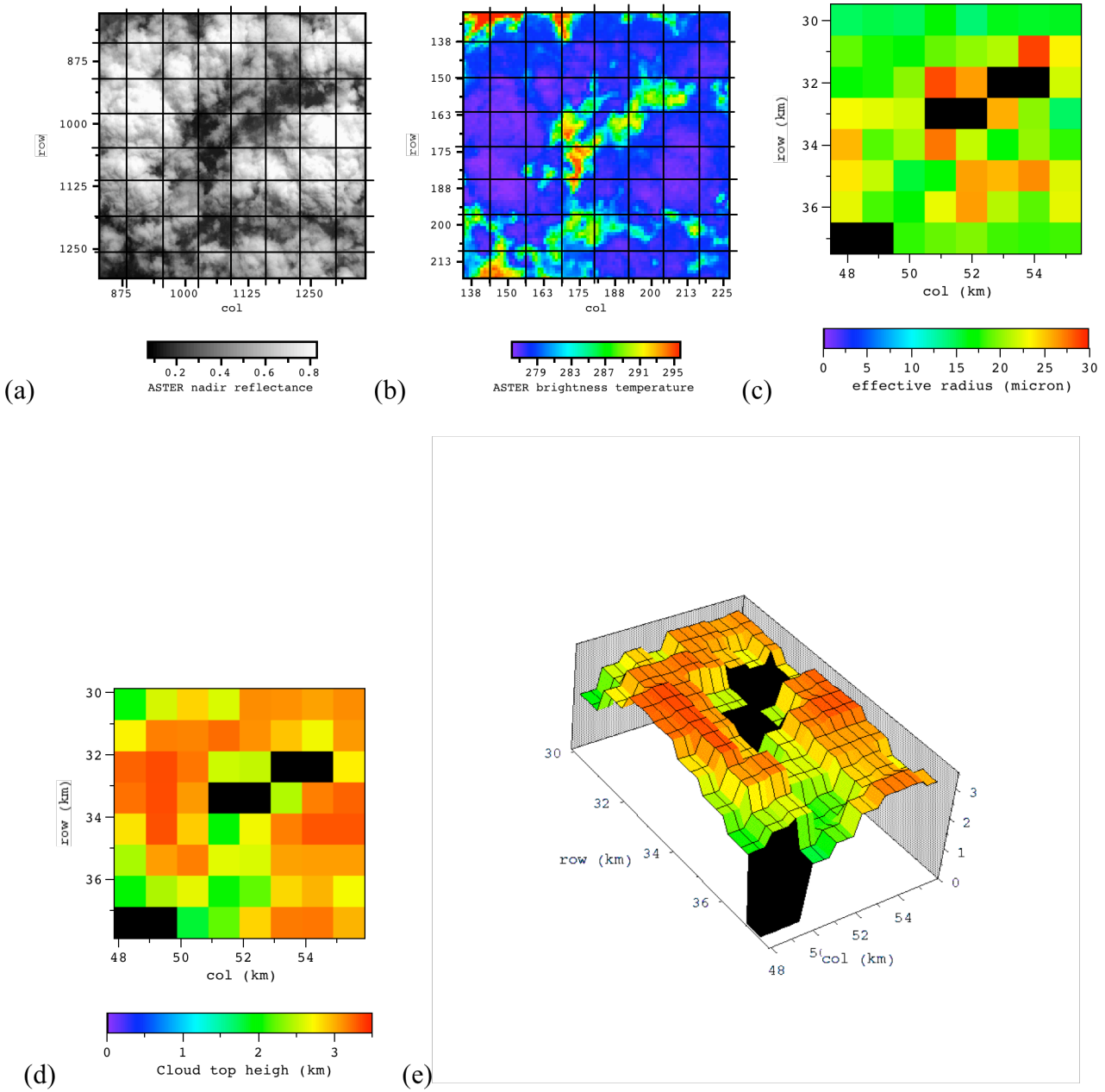




3D effects in droplet size retrievals






(a)
row
875
1000
1125
1250
col
875 1000 1125 1250
0.2 0.4 0.6 0.8
ASTER nadir reflectance
(b)
row
138
150
163
175
188
200
213
col
138 150 163 175 188 200 213 225
279 283 287 291 295
ASTER brightness temperature
(c)
row (km)
30
32
34
36
col (km)
48 50 52 54
0 5 10 15 20 25 30
effective radius (micron)
(d)
row (km)
30
32
34
36
col (km)
48 50 52 54
0 1 2 3
Cloud top heigh (km)
(e)
30
32
row (km) 34
36
48
52
54
col (km)
0
1
2
3

Conclusions

MODIS allows statistical analysis 3D radiative effects.

For oblique sun, cloud heterogeneity influences view-angle dependence of MODIS cloud optical thickness.

1D framework appears insufficient to explain observations.

3D radiative effects appear consistent with observations.

3D effects likely influenced droplet size retrievals in Brazilian scene.